(19) Europäis h s Pat ntamt
European Patent Offi
Office eur pé n d brevet

(11) EP 0 562 695 B1

J1017 U.S. PTO
10/090128
03/05/02

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
06.08.1997 Bulletin 1997/32

(51) Int Cl.[6]: **G02F 1/225**

(21) Application number: **93200862.6**

(22) Date of filing: **26.03.1993**

(54) **Controllable polarisation transformer**

Regelbarer Polarisationswandler

Transformateur de polarisation commandable

(84) Designated Contracting States:
AT BE CH DE DK ES FR GB GR IE IT LI LU NL PT SE

(30) Priority: **27.03.1992 NL 9200576**

(43) Date of publication of application:
29.09.1993 Bulletin 1993/39

(73) Proprietor: **Koninklijke PTT Nederland N.V.**
2509 CH Den Haag (NL)

(72) Inventor: **Van der Tol, Johannes Jacobus Gerardus Maria**
NL-2728 MP Zoetermeer (NL)

(56) References cited:
GB-A- 2 090 992

- **PATENT ABSTRACTS OF JAPAN vol. 7, no. 192 (P-218)(1337) 23 August 1983 & JP-A-58 091 426**
- **APPLIED PHYSICS LETTERS. vol. 59, no. 11, 9 September 1991, NEW YORK US pages 1278 - 1280 , XP000232845 Y.SHANI ET AL. 'Polarization rotation in aeymmetric periodic loaded rib waveguides'**
- **IEEE PHOTONICS TECHNOLOGY LETTERS vol. 3, no. 1, January 1991, NEW YORK US**
- **pages 15 - 16 M. SCHLAK ET AL. 'Tunable TE/TM-Mode Converter on (001)-InP- Subetrete'**
- **PATENT ABSTRACTS OF JAPAN vol. 13, no. 540 (P-969)5 December 1989 & JP-A-01 222 216**

EP 0 562 695 B1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Printed by Jouve, 75001 PARIS (FR)

Description

A. Background of the invention

1. Field of the invention

The invention is in the field of optical transmission systems and, more particularly but not exclusively, of those systems in which coherent detection is used. The invention relates to an optical device for controllably transforming the polarisation of an optical signal.

2. Prior art

In a coherent optical receiver, a received signal and the signal originating from a local oscillator can be ideally combined only if the polarisation states of the signal are identical. The received signal normally enters via a non-polarisation-maintaining light path, with the result that the polarisation state of said signal is undefined on reception. One of the solutions to this problem is achieved by polarisation control, in which case the polarisation state of one of the two signals is altered in such a way that it corresponds to that of the other signal. Such a solution in which the polarisation state of the local oscillator signal is altered is disclosed in reference [1]. The polarisation control disclosed therein is carried out using a controllable polarisation transformer which is driven via a feedback loop. In addition to some controllable polarisation transformers constructed using discrete components, this reference describes an integrated optical version which is based on lithium niobate and which is disclosed in more detail in reference [2]. This known transformer comprises a controllable polarisation mode converter sandwiched between two separately controllable phase shifters. Both the phase shifters and the polarisation mode converter are based on electrooptical modification of the propagation of the TE component and the TM component in a monomodal channel-type waveguide. The actual conversion of a fraction of one polarisation component into the other polarisation component (TE <-> TM) takes place in the polarisation mode converter. In an integrated optical version of a coherent optical receiver, not only optical, but opto-electronic and electrical signal processing has to take place on one chip. Since it is at present usual to chose a wavelength in the near infrared for the light signal, with the present prior art an integrated optical receiver provided with such a polarisation transformer can only be produced using of semiconductor material such as indium phosphide (InP). A polarisation mode converter which is based on InP and which makes use of the linear electro-optical effect in said material is disclosed in reference [3]. To produce a controllable polarisation transformer based on the principle disclosed in reference [2], at least one phase shifter must be added thereto. The total length of the converter and the phase shifter is, however, fairly large, approximately 10 mm, compared with the available space on InP substrates which are usual at the present time. There is therefor a need to base a controllabl polarisation transformer on a modified principle which permits a shorter length for such a component when integrated on the basis of semiconductor materials such as InP.

A polarization controller comprising a Mach-Zehnder interferometer having a TE <-> TM converter in one of its branches is known from [4].

B. Summary of the invention

The object of the invention is to provide a controllable polarisation transformer which satisfies the above-mentioned need.

For this purpose, an optical device for controllably transforming the polarisation of an optical signal, comprising first and second channel-type waveguides, waveguide-type polarisation conversion means including a central waveguide coupled to the first channel-type waveguide, an intermediate waveguiding section coupling the central waveguide of the conversion means to the second channel-type waveguide, and control means which are operative in the intermediate waveguiding section, which device is of a type as known from reference [2], has according to the invention the characteristic that the polarisation conversion means include a TX → TY mode converter for converting a first guided mode signal with a polarisation TX into a second guided mode signal with a polarisation TY and in order different from the order of the first guided mode signal, wherein TX and TY are different from each other and selected from TE and TM, the intermediate waveguiding section includes waveguide branching means coupled to the central waveguide of the mode conversion means and provided with two waveguiding branches, and branch coupling means for coupling the two waveguiding branches to the second channel-type waveguide, and the control means include amplitude control means inserted in one of the two waveguiding branches, for controlling a difference in optical path length in the two branches.

In a preferred embodiment the device according to the invention has the characteristic that the control means include further phase control means which are operative in a waveguiding continuation of the central waveguide included between the mode converter and the waveguide branching means, for controlling a phase between two guided mode signals which differ in mode order.

In a forward signal direction, i.e. using the first waveguide channel as a signal input and the second waveguide channel as a signal output, the device transforms an input light signal comprising, in an unknown ratio, a first signal component propagating in a first guided mode with a polarisation TX (TE or TM) and a second signal component propagating in a second guided mode with a polarisation TY (TM or TE) into an output light

signal propagating with a predetermined polarisation TY. In a reciprocal signal direction, i.e. using the second waveguide channel as a signal input and the first waveguide channel as a signal output, the device transforms an input light signal propagating with a polarisation TX (TE or TM) into an utput light signal having any desired polarisation. As a result of not using the phase control means in the reciprocal application or of not incorporating it In the device, an optical device is obtained which is very suitable for polarisation modulation or switching.

The invention makes use of the fact that reference [3] discloses a passive mode converter with which the first signal component having one polarisation in an entering light signal can be converted into a signal component having the other polarisation without appreciably modifying the second signal component having said other polarisation in said light signal, provided the conversion takes place to another order of the guided mode. With complete conversion, the light signal at the output of such a mode converter contains only signal components of the same polarisation, albeit in guided modes of different order. The principle of the invention is generally applicable; in preferred embodiments the conversion will be between guided modes of the 0th- and the 1th- order. Then the guided modes can easily be combined with the aid of a Mach-Zehnder interferometer if the total light signal is distributed with equal intensity over two monomodal branches of the interferometer and the light contributions from both branches then come together in phase at the output thereof. This can be achieved, respectively, with the controllable phase shifter incorporated between the mode converter and the interferometer and the optical path-length control in one of the branches of the interferometer. Preferably, the device therefore is, according to the invention, characterised in that the first and second wave-guiding channels are monomodal, the central waveguide and its continuation are bimodal waveguides, the device further comprises a wave-guiding adapter for the gradual transition from the monomodal first wave-guiding channel to the bimodal central waveguide, and the waveguide branching means, the waveguiding branches, the branch coupling means and the amplitude control means constitute a controllable Mach-Zehnder Interferometer wherein the two monomodal wave-guiding branches are monomodal and coupled, on the one hand, to the continuation of the central bimodal waveguide by means of a first symmetrical Y junction and, on the other hand, to said output channel by means of a second symmetrical Y junction.

All the subcomponents of such a controllable polarisation transformer can readily be integrated using materials which are standard in integrated optics. A marked, controllable modification of propagation, such as is needed in the phase shifter and the interferometer, accompanied by a short component length can readily be achieved with the present prior art using semiconductor materials, such as InP, by means of charge carrier injection. In a preferred embodiment, the controllable polarisation transformer is therefore characterised in this sense.

The device according to the invention provides a controllable polarisation transformer which can readily be integrated using known procedures, it being possible to achieve the waveguide structure in a single etching step, there being no critical parameters in the manufacture and the control currents required for control being relatively low in the case of integration on semiconductor material such as InP.

C. References

[1] N.G. Walker and G.R. Walker, "Polarisation control for coherent optical fibre systems", Br. Telecom Technol. J., Vol 5, No. 2, April 1987, pp. 63-76;
[2] GB-A-2090992 entitled: "Polarisation transformer";
[3] EP-A-0513919 (by the applicant) entitled: Mode converter;
[4] JP-A-58 91 426.

D. Short description of the drawing

The invention will be explained in greater detail by means of the description of an exemplary embodiment with reference to a drawing, wherein:

FIG. 1 shows diagrammatically an optical component according to the invention in a plan view; and
FIG. 2 shows a cross section of a waveguide structure which can be used in the component shown in FIG. 1.

E. Description of an exemplary embodiment

Polarisation control can be used in two ways in coherent optical receivers. As a first possibility, the polarisation state of a received signal having an unknown polarisation can be adjusted by polarisation control to the polarisation state of the signal originating from the local oscillator. As a second possibility, the polarisation state of the local oscillator signal can be tuned to that of the received signal having the unknown polarisation. FIG. 1 shows diagrammatically a plan view of the structure of a controllable polarisation transformer according to the invention, which polarisation transformer can be used in each of the two methods of polarisation control. The first possibility can be implemented with a signal direction from left to right. The second possibility, if the transformer is used reciprocally, with a signal direction from right to left. As is shown diagrammatically in FIG. 1, the polarisation transformer comprises, between a monomodal channel-type incoming waveguide 1 and a similar outgoing waveguide 2, the following wave-guiding sections consecutively and adjoining one another:

- a wave-guiding adapter 3 from a monomodal to a bimodal waveguide;
- a mode converter 4 which converts only the TX_{00} component of a signal having the signal components in the TX_{00} guided mode and the TY_{00} guided mode into a signal component which propagates further in a TY_{01} guided mode while the TY_{00} component remains unaffected; both TX and TY stand here for one of the polarisations TE or TM, TX not being identical to TY;
- a controllable phase shifter 5 in which the phase can be controlled between signal components propagating in the guided modes TY_{00} and TY_{01} by means of phase control means 6 (broken-line rectangle);
- a Mach-Zehnder interferometer 7 having wave-guiding branches 8 and 9, the optical pathlength in the branch being controllable in the branch 9 by means of the control means 10 (broken-line rectangle).

For the mode converter 4, a passive 100% converter is preferably chosen which is of a type such as is disclosed in reference [3]. To implement the invention, two mode converters can be used, viz. the $TE_{00} \rightarrow TM_{01}$ mode converter and the $TM_{00} \rightarrow TE_{01}$ mode converter. For the sake of convenience, the controllable polarisation transformer provided with a $TM_{00} \rightarrow TE_{01}$ mode converter will be described in the further description of the exemplary embodiment. Said mode converter has a central bimodal waveguide 11 having a periodically varying geometrical structure in its longitudinal direction, this being indicated in the figure by a number of alternating repetitive constrictions and widenings of the waveguide 11 over the length.

The phase shifter 5 may be constructed as a bimodal waveguide 12, which may simply be the continuation of the central bimodal waveguide 11 of the mode converter, assuming that the refractive index can be altered therein with a sufficiently marked effect using suitable control means, so that the mutual phase between the signal components, emerging from the mode converter, of different guided modes having the same polarisation can be adjusted therewith.

The interferometer 7 adjoins the bimodal waveguide 12 by means of a symmetrical Y junction 13 which splits the bimodal waveguide 12 into two monomodal waveguides forming the decoupled branches 8 and 9. These monomodal wave-guiding branches 8 and 9 are brought together again by means of a symmetrical Y junction 14 and converted into the monomodal outgoing guide 2.

The operation is as follows:

Given a signal direction from left to right, a signal having unknown polarisation is converted into a signal in the TE polarisation state. A signal entering via the monomodal channel-type waveguide 1 and having an unknown polarisation generally contains a TE_{00} component and a TM_{00} component of arbitrary relativ strength and having arbitrary relative phase. Said signal propagates via the adapter 3 into the bimodal waveguide 12 of the mode converter 4. In the mode converter 4, the TM_{00} component is converted into a TE_{01} component, while the TE_{00} component remains virtually unaltered. The TE_{01} component obtained, however, still has an unknown intensity and phase compared with the TE_{00} component. If the mutual phase difference between the TE_{00} component and the TE_{01} component is adjusted to $+\pi/2$ or $-\pi/2$ in the phase shifter 5 with the aid of the control means 6, beyond the phase shifter the signal will distribute itself via the symmetrical Y junction 13 into signal parts having equal power over the two branches 8 and 9 of the interferometer 7. If the optical pathlength difference between the branches 8 and 9 is adjusted in the branch 9 with the aid of the control means 10 in such a way that the two signal parts arrive in phase at the Y junction 14, the two signal parts will combine to form a maximum signal which propagates further in the TE_{00} guided mode in the outgoing waveguide 2. For use as a polarisation controller, the control means 6 and 10 of the controllable polarisation transformer are adjusted to a maximum signal in the outgoing waveguide.

In the case of a reciprocal use of the transformer, this being with a signal direction from right to left, a signal having known polarisation, in this case the TE polarisation, can be transformed into a signal in any desired polarisation state by adjusting the control means 6 and 10. A signal in the TE polarisation entering via the waveguide 2 is split in the Y junction 14 into signal parts of identical intensity and guided mode, which propagate further along the branches 8 and 9 of the interferometer 7. Depending on the relative phase difference with which said signal parts are again combined in the Y junction 13, the combined signal propagates in the bimodal waveguide 12 of the phase shifter 5, either exclusively in the TE_{00} mode (for a relative phase difference of $2k\pi$ rad, where $k = 0, \pm 1, \pm 2$, etc.) or exclusively in the TE_{01} mode (for a relative phase difference of $(2k+1)\pi$ rad, where $k = 0, \pm 1, \pm 2$, etc.) or in a mixed signal having signal components in the TE_{00} mode and the TE_{01} mode, and with an amplitude ratio which is directly dependent on the relative phase difference. Said phase difference can be adjusted by controlling the optical wavelength difference between the branches 8 and 9 with the aid of the control means 10. In the mode converter 4, the signal component in the TE_{01} mode is converted into a signal component in the TM_{00} mode, while the other signal component in the TE_{00} mode of the mixed signal passes through the mode converter unchanged. Both signal components propagate further in unchanged form via the first adapter 3 and the monomodal waveguide 1. The relative phase difference which exists between the two signal components on passing through the adapter 3 can be adjusted with the aid of the control means 6 of the phase shifter 5. A signal which enters with a TE polarisation via the waveguide 2 can therefore be trans-

formed by an amplitude control with the aid of the control means 10 and a phase control with the aid of th control means 6 into a signal which has any desired polarisation state and issues via the waveguide 1. If the phas control with the aid of the control means 6 is omitted or if the control means 6 are absent, the polarisation transformer is very suitable in the reciprocal direction for polarisation modulation such as is used, for example, in 'data induced polarisation switching' (DIPS) procedures. By controlling the amplitude with the aid of the control means 10 in the interferometer, electrical signals corresponding to binary "0" and "1" can be interpreted as corresponding TE_{00} and TE_{01} signals. In the mode converter 4, a TE mode and a TM mode are then produced as a representation of these binary values.

All the wave-guiding sections of the polarisation transformer as shown diagrammatically in FIG. 1 can in principle be produced entirely with known integration techniques and using standard waveguide materials and structures in the process. However, the restriction applies that the waveguide materials with which at least the phase shifter 5 and branch 9 of the interferometer 7 are produced must always have the possibility of the abovementioned phase and optical path length controls. Theoretically, the desired controls can be achieved by modifying the light propagation in the respective waveguides by means of electro-optical, thermo-optical, opto-optical, etc., effects with suitable choice of the material of the waveguide or of its surroundings and the matching modifying means. Preferably, however, use is made of electro-optical effects and, more particularly, of charge carrier injection into the semiconductor material. If a material such as InP is used, the entire waveguide structure of the polarisation transformer in FIG. 1 can be produced with the same type of ridge-type waveguide, whose cross section is shown in FIG. 2. Situated between a substrate 21 and an upper layer 22, both composed of InP, is a light-guiding layer 23 composed of InGaAsP and having thickness t. Over the entire length of the waveguide structure, the upper layer 22 has in places a ridge-type platform 22.1 having a fixed height h with a total height H, and having a width w which varies for the various successive waveguides 1, 3, 11, 12, 8, 9 and 2. For the purpose of charge carrier injection into the bimodal waveguide 12 and the monomodal waveguide 9, a planar electrode 24 extends over the underside of the substrate 11, at least under a part of each of the waveguides 9 and 12, for example as indicated by the broken-line rectangles indicating the control means 10 and 6 in FIG. 1. Situated above the planar electrode 24 on the ridge-type platform of each of the waveguides 9 and 12 is a strip-type electrode 25. A controllable current source can be connected to the electrodes 24 and 25 in the case of each of the waveguides 9 and 12 via supply and drain leads (not shown) in order to supply a current with which, as is known, charge carrier injection into the upper layer 22 can be achieved at the position of the ridge-type platform 22.1, as a consequence of which an alteration of the refractive index is brought about. Thus, each of the control means 6 and 10 comprises an electrode pair 24 and 25. The electrode 25, which forms part of the control means 10, is not critical and can be chosen as narrow compared with the width w as shown, but preferably has the same width as the ridge-type platform 22.1. The electrode 25, which forms part of the control means 6, is preferably constructed either as a single narrow strip situated in the centre above the ridge-type platform 22.1 of the bimodal waveguide 12, or as two narrow, electrically coupled strips situated near the edges of the ridge-type platform 22.1. In both embodiments, an effective, controllable phase shift can be achieved by means of a charge carrier injection between the two modes propagating in the bimodal waveguide 12, viz. the TE_{00} mode and the TE_{01} mode. This is based on the fact that, as is known, the field strength distribution of the zeroth-order mode and that of the first-order mode exhibit a characteristic difference in such a waveguide. Specifically, in the centre of such a channel-type guide, the field strength associated with the first-order propagation mode is zero but that of the zeroth-order propagation mode, on the other hand, is a maximum. This therefore provides the possibility of modifying essentially only the propagation constant of one of the two guide modes in the waveguide, that is to say of the zeroth-order (single strip) or the first-order mode (two strips), and consequently modifying the relative phase difference between said propagation modes.

Example:

The following values serve to illustrate a controllable polarisation transformer having a structure as described on the bases of FIG. 1 and FIG. 2 and suitable for light signals having a wavelength of 1.5 μm:
for the ridge-type waveguide structure

- refractive index of InP $n_1 = 3.1753$,
- refractive index of InGaAsP $n_2 = 3.4116$,
- $t = 0.473$ μm, $H = 0.504$ μm, $h = 0.2$ μm.

Said ridge-type waveguide structure can be produced in one etching step, the width w being the sole variable parameter:

- the incoming waveguide 1 must be monomodal for TE and TM; therefore w = 4.3 μm maximum;
- the adapter 3 must adapt from monomodal to bimodal, the bimodal channel preferably having a width which is such that said channel is bimodal only for the TE polarisation; a width of w = 8.5 μm is suitable for this purpose, while approximately 1° is chosen as the adaptation angle for the transition; consequently, the length of the adapter is approximately 200 μm;
- the mode converter 4 is a 100% $TM_{00} \rightarrow TE_{01}$ mode

converter having N = 11 coupling surfaces and a coupling length of L = 91 μm; in the periodically varying structure of widenings and constrictions, each widening has a width of w = 8.5 μm and each constriction has a width of w = 6 μm; the total length of the mode converter is approximately 1000 μm;

- the central bimodal waveguide 12 of the phase shifter 5 has a width w = 8 μm and a length of approximately 1 mm; the strip-type electrode 25, which forms part of the control means 6, is situated over the entire length of the ridge-type platform 22.1 of the bimodal waveguide 12 and has a width of 3 μm; the length of the strip-type electrode 25 is determined by the fact that, as a minimum, a phase difference of $\pi/2$ must be capable of being achieved between the TE_{00} mode and the TE_{01} mode;
- the Y junction 13 has a splitting angle of approximately 1° and transforms the bimodal waveguide 12 into the monomodal wave-guiding branches 8 and 9 up to a mutual spacing of approximately 10 μm, with the result that said branches are decoupled; the length of the Y junction 13 is consequently approximately 500 μm;
- the waveguides of the branches 8 and 9 have a width of 4.3 μm < w < 6 μm; the strip-type electrode 25, which forms part of the control means 10, is situated over a length of approximately 50 μm of the ridge-type platform 22.1 of the monomodal waveguide of the branch 9, in that part in which the branches 8 and 9 are decoupled, and has a width equal to the width of the ridge-type platform at this point; the length of approximately 50 μm of the strip-electrode 25, which forms part of the control means 10, is determined by the fact that, as a minimum, an optical path length difference corresponding to a phase difference of π rad must be capable of being achieved between the branches 8 and 9;
- the Y junction 14 also has a splitting angle of approximately 1° and transforms the monomodal waveguides of the branches 8 and 9 into the monomodal outgoing waveguide 2; the length of the Y junction 14 is consequently approximately 600 μm;
- the outgoing waveguide 2 has to be monomodal in the present example only for the TE polarisation; this is achieved with a width w = 6 μm as a maximum.

The other dimensions of the strip-type electrode 25 and the choice of material for the electrodes are in fact not relevant to the control action of the respective control means of which the electrode forms part; a thickness of approximately 200 nm is normally to be chosen with a layered structure of Ti (2-5 nm), Pt (2-5 nm) and Au.

The total length of such a controllable polarisation transformer is therefore approximately 3.35 mm, which is appreciably shorter than that which can reasonably be expected of a known electro-optical controllable transformer. This shortening is achieved primarily as a result of a combination of effects which are much more marked than the linear electro-optical effect, viz. a polarisation conversion by means of a passive mode conversion and an active phase adjustment by means of charge carrier injection.

Claims

1. Optical device for controllably transforming the polarisation of an optical signal, comprising:

   first and second channel-type waveguides (1, 2),
   waveguide-type polarisation conversion means (4) including a central waveguide (11) coupled to the first channel-type waveguide,
   an intermediate waveguiding section (5, 7) coupling the central waveguide of the conversion means to the second channel-type waveguide, and
   control means (6, 10) which are operative in the intermediate waveguiding section,

   characterized, in that

   the polarisation conversion means include a TX → TY mode converter (4) for converting a first guided mode signal with a polarisation TX into a second guided mode signal with a polarisation TY and in order different from the order of the first guided mode signal, wherein TX and TY are different from each other and selected from TE and TM,
   the intermediate waveguiding section includes waveguide branching means (13) coupled to the central waveguide (11) of the mode conversion means and provided with two waveguiding branches (8, 9), and branch coupling means (14) for coupling the two waveguiding branches to the second channel-type waveguide (2), and the control means include amplitude control means (10) inserted in one (9) of the two waveguiding branches, for controlling a difference in optical path length in the two branches.

2. Optical device according to Claim 1, **characterized** in that the control means include further phase control means (5) which are operative in a waveguiding continuation (12) of the central waveguide (11) included between the mode converter (4) and the waveguide branching means (13), for controlling a phase between two guided mode signals which differ in mode order.

3. Optical device according to Claim 2, **characterized** in that the first and second wave-guiding channels (1, 2) are monomodal,

in that the central waveguide (11) and its continuation (12) ar bimodal waveguides,
in that the device further comprises a waveguiding adapter (3) for the gradual transition from the monomodal first wav -guiding channel (1) t the bimodal central wav guide (11), and
in that the waveguide branching means (13), the waveguiding branches (8, 9), the branch coupling means (14) and the amplitude control means (10) constitute a controllable Mach-Zehnder interferometer wherein the two wave-guiding branches (8, 9) are monomodal and coupled, on the one hand, to the continuation (12) of the central bimodal waveguide (11) by means of a first symmetrical Y junction and, on the other hand, to said output channel (2) by means of a second symmetrical Y junction.

4. Optical device according to Claim 3, **characterised** in that the device includes a pattern of waveguides constructed in semiconductor material, and in that the amplitude and phase control means are electrode means (24, 25) for achieving a charge carrier injection into the respective waveguides.

Patentansprüche

1. Optisches Gerät zur steuerbaren Wandlung der Polarisation eines optischen Signals mit:

   ersten und zweiten Kanalwellenleitern (1, 2),
   wellenleiterartigen Polarisationswandlermitteln (4) mit einem zentralen Wellenleiter (11), der mit dem ersten Kanalwellenleiter gekoppelt ist,
   einem dazwischenliegenden wellenleitenden Abschnitt (5, 7), der den zentralen Wellenleiter der Wandlermittel mit dem zweiten Kanalwellenleiter koppelt, und
   Steuermitteln (6, 10), die in dem dazwischenliegenden wellenleitenden Abschnitt wirken,

   dadurch gekennzeichnet, dass

   die Polarisationswandlermittel einen TX->TY-Modenwandler (4) aufweisen, um ein erstes geführtes Modensignal mit einer Polarisation TX in ein zweites geführtes Modensignal mit einer Polarisation TY und in einer unterschiedlichen Ordnung gegenüber der Ordnung des ersten geführten Modensignals zu wandeln, wobei TX und TY zueinander unterschiedlich sind und aus TE und TM ausgewählt sind,
   dass der dazwischenliegende wellenleitende Abschnitt ein Wellenleiterverzweigungsmittel (13) aufweist, das mit dem zentralen Wellenleiter (11) des Modenwandlermittels verbunden ist und mit zwei wellenleitenden Armen (8, 9) und armverbindenden Mitteln (14) ausgestattet ist, um die beiden Wellenleiterarme in einen zweiten Kanalwellenleiter (2) zu koppeln, und dass die Steuermittel Amplitudensteuermittel (10) aufweisen, die in einem (9) der beiden Wellenl iterarme ingefügt sind, um eine Differenz der optischen Weglänge in den zwei Armen zu steuern.

2. Optisches Gerät nach Anspruch 1, dadurch gekennzeichnet, dass die Steuermittel weiterhin Phasensteuermittel (5) aufweisen, die in einer Wellenleiterverlängerung (12) des zentralen Wellenleiters (11) zwischen dem Modenwandler (4) und dem Wellenleiterverzweigungsmittel (13) eingefügt sind, um eine Phase zwischen den geführten Modensignalen zu steuern, die in der Modenordnung differieren.

3. Optisches Gerät nach Anspruch 2, dadurch gekennzeichnet, dass die ersten und zweiten wellenleitenden Kanäle (1, 2) monomodal sind, dass der zentrale Wellenleiter (11) und seine Verlängerung (12) bimodale Wellenleiter sind, dass das Gerät weiterhin einen Wellenleiteradapter (3) für den graduellen Übergang von dem monomodalen ersten Wellenleiterkanal (1) zu dem bimodalen zentralen Wellenleiter (11) aufweist, und dass die Wellenleiterverzweigungsmittel (13), die Wellenleiterarme (8, 9), die Wellenleiterkoppelmittel (14) und die Amplitudensteuermittel (10) ein steuerbares Mach-Zehnder-Interferometer bilden, bei dem die zwei Wellenleiterarme (8, 9) monomodal sind und auf der einen Seite in die Verlängerung (12) des zentralen bimodalen Wellenleiters (11) durch das Mittel einer ersten symmetrischen Y-Verbindung und auf der anderen Seite mit dem besagten Ausgangskanal (2) durch eine zweite symmetrische Y-Verbindung angekoppelt sind.

4. Optisches Gerät nach Anspruch 3, dadurch gekennzeichnet, dass die Vorrichtung ein Muster von Wellenleitern umfasst, die aus Halbleitermaterial bestehen und dass die Amplitude und Phasensteuermittel Elektrodenmittel (24, 25) sind, um eine Ladungsträger-Injektion in die jeweiligen Wellenleiter zu erzeugen.

Revendications

1. Dispositif optique pour transformer de façon contrôlable la polarisation d'un signal optique comprenant :

   des premier et second guides d'ondes de type à canal (1, 2) ;

des moyens de conversion de polarisation de type à guide d'ondes (4) incluant un guide d'ondes central (11) couplé au premier guide d'ondes de type à canal,
un section de guidage d'ondes intermédiaire (5, 7) couplant le guide d'ondes central des moyens de conversion au second guide d' ndes de type à canal, et
des moyens de commande (6, 10) qui sont actifs dans la section de guidage d'ondes intermédiaire,

caractérisé en ce que :

les moyens de conversion de polarisation comprennent un convertisseur de mode TX - TY (4) pour convertir un premier signal de mode guidé ayant une polarisation TX en un second signal de mode guidé ayant une polarisation TY et dans un ordre différent de l'ordre du premier signal de mode guidé, où les polarisation TX et TY sont différentes l'une de l'autre et sélectionnées à partir des composantes TE et TM,
la section de guidage d'ondes intermédiaire comprend des moyens de branchement de guide d'ondes (13) couplés au guide d'ondes central (11) des moyens de conversion de mode et pourvus de deux branchements de guidage d'ondes (8, 9), et des moyens de couplage de branchement (14) pour coupler les deux branchements de guidage d'ondes au second guide d'ondes de type à canal (2), et
les moyens de commande comprennent des moyens de commande d'amplitude (10) insérés dans l'un (9) des deux branchements de guidage d'ondes, pour commander une différence de longueur de chemin optique dans les deux branchements.

2. Dispositif optique selon la revendication 1, caractérisé en ce que les moyens de commande comprennent en outre des moyens de commande de phase (5) qui sont actifs dans un prolongement de guidage d'ondes (12) du guide d'ondes central (11) inclus entre le convertisseur de mode (4) et les moyens de branchement de guide d'ondes (13), pour commander une phase entre deux signaux de mode guidé qui diffèrent dans l'ordre du mode.

3. Dispositif optique selon la revendication 2, caractérisé en ce que les premier et second canaux de guidage d'ondes (1, 2) sont monomodaux,

en ce que le guide d'ondes central (11) et son prolongement (12) sont des guides d'ondes bimodaux,
en ce que le dispositif comprend en outre un adaptateur de guidage d'ondes (3) pour le passage progressif du premier canal de guidage d'ondes monomodal (1) au guide d'ondes central bimodal (11), et
en ce que les moyens de branchement de guide d'ondes (13), les branchements de guidage d'ondes (8, 9), les moyens de couplage de branchement (14) et les moyens de commande d'amplitude (10) constituent un interféromètre de Mach-Zehnder contrôlable dans lequel les deux branchements de guidage d'ondes (8, 9) sont monomodaux et couplés, d'une part, au prolongement (12) du guide d'ondes bimodal central (11) au moyen d'une première jonction Y symétrique et, d'autre part, audit canal de sortie (2) au moyen d'une seconde jonction Y symétrique.

4. Dispositif optique selon la revendication 3, caractérisé en ce que le dispositif comprend une configuration de guides d'ondes réalisée dans un matériau semiconducteur, et en ce que les moyens de commande d'amplitude et de phase sont des moyens à électrodes (24, 25) pour obtenir une injection de porteurs de charge dans les guides d'ondes respectifs.

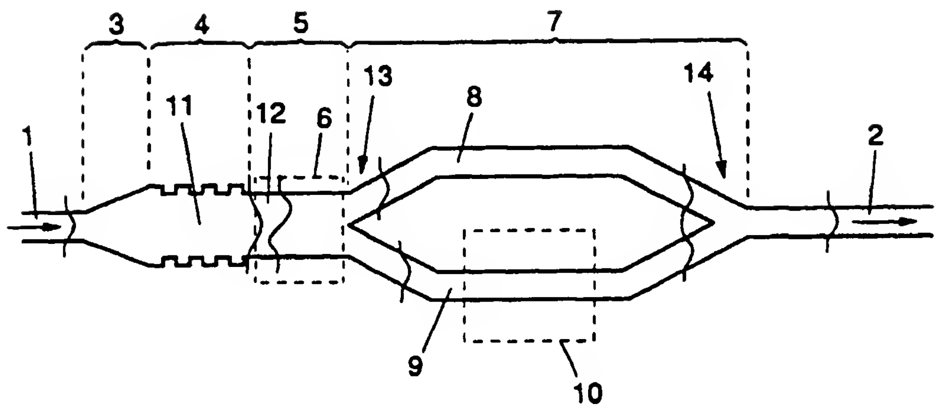

FIG. 1

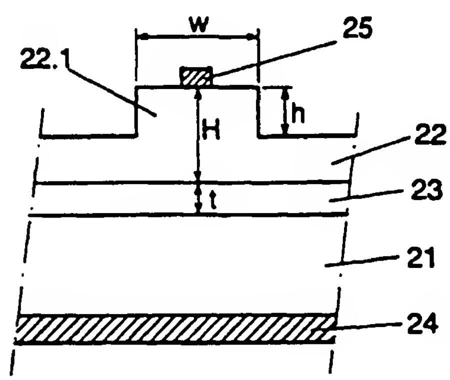

FIG. 2